Measuring Settlement Efficiency. Application to an Urban Regeneration

Federica Cicalese(✉), Michele Grimaldi, and Isidoro Fasolino

University of Salerno, Via Giovanni Paolo II, 132 Fisciano, (SA), Italy
fcicalese@unisa.it

Abstract. Urban regeneration is defined as a set of comprehensive actions aimed at providing solutions and leading to the recovery of physical conditions, and economic activity, the socio-cultural integration of community members and the restoration of environmental quality in places where these aspects have declined. In this context, there is a need to incorporate sustainable development goals into the decision-making process. In fact, there is currently no concrete and applicable tool that planners can use to obtain empirical and measurable results on how to achieve these goals.

This paper proposes a methodology to assess the urban settlements efficiency. The focus is on the settlement, which can be identified as a neighbourhood or an urban area that is the subject of a neighbourhood plan, in an attempt to lead the debate to an operational scale and to reflect on the contents of the plan on a detailed scale. The model uses a system of indicators specifically built from a broad survey of scientific articles and international experience. More than twenty quantitative and qualitative criteria are proposed as the basis for evaluation. This methodology led us to define and calculate the composite settlement efficiency index (EI). Identifying indicators for the urban environment is essential for monitoring urban trends. Their use makes it possible to control both the measurement and evaluation of each system's component's contribution to the overall efficiency of the settlement.

The methodology was applied to an urban regeneration case study, located in Nocera Inferiore (Southern-Italy). The evaluation permits performance comparisons to be made between different project scenarios, and variations on an indicator set basis. The overall goal is to provide the urban planning process with tools for designing livable and inclusive settlements, in line with sustainable development goals.

Keywords: Urban regeneration · Settlement efficiency · Neighbourhood plan

1 Introduction

Nowadays, cities face numerous environmental problems such as pollution, the effects of climate change, and depletion of natural resources that affect the quality of life of people living in urban environments [1]. The ongoing process of global warming, driven by the escalating concentration of greenhouse gases generated by human activities, especially in urban areas, significantly impacts public health.

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2026
O. Gervasi et al. (Eds.): ICCSA 2025 Workshops, LNCS 15893, pp. 249–264, 2026.
https://doi.org/10.1007/978-3-031-97645-2_17

Urban policies aim at climate neutrality by 2050 (Net Zero), managing the energy crisis and improving cities' capacity to absorb CO2 through targeted climate change mitigation and adaptation strategies [2].

In this context, urban planners have a key role to play in creating and maintaining attractive and liveable cities [3] and the most comprehensive and effective tool that governments can adopt is urban regeneration [4, 5]. It can be defined as an integrated and inclusive process that combines physical, environmental, and socio-economic measures [4]. With the potential to advance almost all Sustainable Development Goals (SDGs) of the 2030 Agenda, urban regeneration serves as a multifaceted solution addressing challenges such as social equity, human health, carbon emissions, infrastructure improvement, livability, and housing [6]. It acts as a comprehensive driver for the localization of the SDGs, employing data-driven insights, participatory planning, and targeted interventions to create sustainable urban transformations.

Today, more than ever, it is necessary to address the question of how efficient our settlements are, considering the environmental, social and economic challenges we face every day. The increasing complexity of urban problems calls for a methodological approach that allows for an objective assessment of the efficiency of the adopted strategies. For this reason, it becomes essential to identify suitable measurement tools, through clear and measurable indicators, capable of returning a precise evaluation of the actions adopted.

The use of the term "efficiency" rather than "effectiveness" highlights the critical role that resources play. "Efficiency" refers to the ability to achieve a system of objectives with the minimum expenditure of resources, thereby maximizing the instrumental value of the approach, its productive capacity, and its overall performance [7]. In a setting marked by structural scarcity of resources of all kinds, the relationship between available resources and the objectives to be achieved takes on exceptional importance. Indeed, general settlement inefficiency reflects the outcome of a complex interplay between weaknesses in urban planning, social dynamics, the often unintended consequences of sectoral policies, and the market forces that often intersect with these factors [7].

This article aims to fill the gap in the assessment of measures that exists at the planning and design level. Therefore, a methodology is proposed as a tool to support planners in assessing the efficiency of different design choices in the context of urban regeneration. Through a holistic approach, an attempt is made to offer an overview to guide urban planning towards more sustainable and efficient solutions. Measuring the efficiency of interventions makes it possible not only to monitor the achievement of set objectives, but also to adapt strategies according to specific local needs. An approach based on quantitative and qualitative indicators makes it possible to optimise the use of resources, maximise the benefits for the community and ensure truly sustainable interventions in the long term.

In particular, a definition of the settlement efficiency index (EI) is carried out (Sect. 2), to formulate a synthetic judgement on the overall performance of a portion of an urban area; a comparison of different scenarios of an urban regeneration project is envisaged (Sect. 3). The main results (Sect. 4) of this research concern the possibility of numerically measuring the aspects that influence urban quality at the urban scale, considered the most suitable as a self-sufficient spatial unit to show the results of regeneration.

2 Methodology

In the face of an established awareness dictated by the agenda and the resources planned to achieve the objectives of sustainable development, the need emerges to introduce decision support mechanisms that effectively allow the urban transformation to be evaluated on an urban scale starting from the elements of the project that can effectively contribute to the achievement of sustainability, hereinafter referred to as "urban devices". The methodology relies on three main stages:

- Urban devices measurement
- Construction of different project scenarios
- Construction of a composite index

2.1 Phase 1: Urban Devices Measurement

The methodology consists of 22 urban devices that make up the settlement efficiency model. Then, concerning the nature of the different criteria, 3 homogeneous areas were identified into which the selected indicators could be grouped: Artificial Capital – AC, Natural Capital – NC and Social Capital – SC (Table 1). More precisely, the Artificial Capital is understood as the set of artefacts created by man to raise the quality of life. About Natural and Social Capital, reference is made to concepts already present in the literature [8–10] that refer to the role of nature in urban areas and to the heritage of knowledge and awareness of settled communities.

Qualitative and quantitative indicators have been identified for their measurement [11]. Identifying indicators for the urban environment is crucial to monitor urban trends and manage the measurement and evaluation of the contribution of each component to the overall functioning of the settlement, in a controlled manner. They were specifically developed through an extensive review of scientific literature and international experiences. They have also been selected taking into account that the sustainable design of spaces must: adapt to climate change; ensure an adequate level of soil permeability; allow the collection of rainwater as a result of massive storms; generate spaces to manage emergencies, suitable for gathering a huge number of people in safe conditions.

Many existing approaches focus on single aspects of sustainability, tending to privilege only one of the capitals or to consider them separately. Instead, the proposed methodology systematically integrates the three components - artificial, natural and social capital - allowing for a holistic assessment of the quality and efficiency of a settlement. Moreover, the methodology only includes indicators that can be monitored and modified by implementing urban planning tools (e.g. permeable surface, functional mix, etc.). This ensures consistency between assessment and intervention possibilities, filling an operational gap that many theories leave open.

To obtain a comprehensive evaluation of the performance of each urban device and to assess the success and efficiency of specific design choices, performance bands were assigned. An equal number of performance bands were established, with threshold values derived from existing literature when available. For qualitative criteria, efforts were made to translate them into corresponding quantitative ranges. The four performance bands are scored from 0 to 3, where a score of 0 shows that the calculated value is zero or insufficient relative to the efficiency objectives, while a score of 3 reflects performance

Table 1. The 22 urban devices categorised by capital

Artificial capital		Natural Capital		Social Capital	
1	Cycle paths	13	Permeable surfaces	18	Multifunctional square
2	Pedestrian spaces	14	Ecological habitat	19	Urban center
3	Intermodal nodes	15	Urban gardens	20	Functional mixité
4	Recycling and composting infrastructure	16	Ecological micro-corridors	21	Social mixité
5	Building geometry	17	Tree density	22	Water square
6	Urban compactness				
7	Photovoltaic roof				
8	District heating				
9	Water mirrors				
10	Green roof				
11	Sustainable urban drainage system				
12	Water collection and reuse system				

most aligned with the efficiency goals. For qualitative indicators, the score remains consistent: a score of 0 indicates the absence of the evaluated indicator, while a score of 3 indicates a high presence.

Artificial Capital

The *artificial* capital derives from the transformation of natural capital (e.g., houses, roads, bridges). In this category is possible to identify four main themes: energy, mobility, water and waste management. Each consists of one or more urban devices, representing particular features of an efficient neighbourhood, in order to ensure the realisation of the overall principles and objectives [12].

The "energy" sub-category encompasses the use of passive design strategies, district heating and cooling systems and the use of photovoltaic roofs. Appropriate passive design considerations account for key building parameters such as building structure and orientation, district heating and cooling system. The methodology also considers elements such as urban compactness by promoting solutions that reduce land consumption and settlement dispersion [13].

The "waste management" encompasses the implementation of recycling and composting infrastructures while the "water" sub-category takes into account different aspect of sustainable water management, that's an integral aspect of the overall drive toward

sustainable development [12]. Water management includes implementing water conservation strategies and the use of water-efficient devices, through sustainable urbane drainage system, water collection and reuse system, mirror of waters and green roofs.

Then, the "mobility" sub-category takes into account pedestrian spaces, cycle paths and internodal modes. These are an essential factor in a community's transportation infrastructure and are vital components to promote physical and mental health [12]. They reduce traffic congestion by providing an alternate mode of travel, which accordingly reduces the associated atmospheric pollution and provides a healthier living environment with more clean, fresh air to breathe in.

Natural and Social Capital

Natural capital, includes ecosystems, biodiversity, and environmental matrices essential for preserving natural resources [14, 15]. Tree-lined streets provide an attractive and shaded walking environment. They provide a visual wall and clear edges to sidewalks which helps motorists control their speed, hence creating safer walking environments. In addition, the trees close proximity to moving vehicles allows them to absorb harmful pollutants released from their tailpipe emissions. Trees are also highly effective at obscuring unappealing vertical street features such as lighting and utility poles [12].

The *social* capital, encompasses the wealth of knowledge and interactions within settled communities [9, 16, 17]. Here are taken into account the presence of water square, multifunctional square, urban center, and the functional and social mixite.

2.2 Phase 2: Construction of Different Project Scenarios

In the context of urban regeneration, scenarios are used to predict the effects of different design configurations and interventions on urban areas. This method is an essential tool, as it allows us to model hypothetical scenarios by evaluating the effects produced by different strategies on urban settlement. Through this process, we can identify which urban devices have a more or less significant impact on achieving settlement sustainability.

Scenarios allow for exploring preferences between alternative strategies in the context of a range of future worlds: some representing how they would like their political and social environment to evolve, others less desirable futures [18]. They can be used to help the decision maker develop a better understanding of the complex relationships among uncertainties, objectives and strategic options [19]. By having alternative policies, the decision makers can better understand the range of possibilities and the diverse interests of the stakeholders [20]. When combined with option planning and a clear, structured view of what is desirable, scenarios provide a coherent framework for evaluating strategic options [19].

The methodology relies on three project scenarios:

- *Scenario 0 - Trend* represents the design choices in the study area relative to the planivolumetric distribution of buildings on the territory according to the sizing and proportioning calculations, as established by the Technical Implementation Regulations (NTA).
- *Scenario 1 - Intermediate*, proposes to improve the efficiency index calculated in the previous scenario, imagining to design interventions to be carried out in the "short term".

– *Scenario 2 - Final*, the last scenario developed, is proposed as an evolution of the previous scenarios, implementing actions aimed at the progressive improvement of the district's energy and environmental performance, imagining the design of interventions to be implemented in the "long term". The objective is thus to realise a scenario of maximising settlement efficiency, making the most of certain solutions and urban devices.

2.3 Phase 3: Construction of a Composite Index

The last phase of the model construction concerns the definition of the Settlement Efficiency Index (EI), a key parameter to evaluate the overall performance of the scenarios developed in the previous stage.

This index plays a key role in urban planning, as it provides a numerical framework that summarises how well each scenario meets the objectives of sustainability, quality of public space and efficiency of infrastructure. Using a summary parameter makes it possible to compare the various urban configurations objectively and to identify which design solutions have the greatest positive impact on the context under consideration.

Since the indicators considered come from different thematic areas and have different units of measurement, it is essential to adopt an aggregation method that allows the various dimensions of urban sustainability to be compared. This is necessary to harmonise data on distinct urban phenomena, such as energy efficiency, biodiversity and social inclusion, which cannot be directly compared due to their different nature.

The aggregation of the data is done through normalisation techniques that make the different values homogenous, thus allowing a comparative analysis and the creation of an overall index that accurately represents the quality of the urban scenario as a whole.

The normalised total efficiency index ($EI_{t,n}$) can be evaluated through the weighted sum of three indices:

$$EI_{t,n} = \sum w_k EI_{k,n} = w_{CA} EI_{CA,n} + w_{CN} EI_{CN,n} + w_{CS} EI_{CS,n} \tag{1}$$

where:

k = identified thematic areas (Artificial Capital - CA, Natural Capital - CN and Social Capital - CS);

w = weights assigned to the three capitals;

$EI_{k,n}$ = normalised efficiency index referring to the k-th capital.

The normalised index $EI_{k,n}$ related to each capital k (k = CA, CN, CS) is calculated by dividing the total score obtained in the analysed scenario ($p_{m,k}$) for the total score of the maximised scenario ($p_{m,k_{max}}$):

$$EI_{k,n} = \frac{\sum_{m=1}^{24} p_{m,k}}{\sum_{m=1}^{24} p_{m,k_{max}}} \tag{2}$$

3 Application

The case study concerned an urban regeneration hypothesis of an area located in the municipality of Nocera Inferiore, in southern Italy (see Fig. 1a). Following an analysis of the structural framework of the Municipal Urban Plan (PUC), it emerges that the

area examined is class D7 'Reused disused industrial areas'. In particular, they include disused industrial complexes variously subdivided and destined for tertiary activities, with occasional arrangements of the covered surfaces, almost entirely paved and used as pertaining parking and manoeuvring spaces.

The intervention area (see Fig. 1b) consists of 2 compartments: the first, with an area of 40,687 square metres, and the second, further south, covers an area of 31,296 square metres, for a total of 71,983 square metres. Currently, the area is marked by the presence of disused or underused production lots, which are located within a consolidated urban fabric.

3.1 Scenario 0

The first scenario (see Fig. 2) was drawn up on the basis of the Technical Implementation Regulations (NTA) of the Municipal Urban Plan (PUC) of the Municipality of Nocera Inferiore.

The planned interventions, therefore, follow the regulatory prescriptions without introducing significant innovations. A percentage of permeable surfaces equal to 35% is guaranteed, and the tree planting index (0.005 trees/sqm) is respected, ensuring the insertion of trees in the subdivision. Although at this early stage, the presence of greenery is still limited compared to future scenarios, the inclusion of green spaces is crucial for improving air quality and creating more liveable environments. Increased tree cover provides natural shade, lowering temperatures in public areas during the summer and making open spaces more usable.

From a functional and social point of view, Scenario 0 manages to maintain a good balance between different uses. Fifty per cent of the gross usable surface (Slp) is dedicated to the residential function, with 15% reserved for social housing (Ers). This is crucial to ensure greater housing accessibility, promoting social inclusion and offering residential opportunities also to those who have difficulty accessing the housing market. The remaining 50% of the Slp is intended for non-residential functions, such as relational offices, commercial activities and public establishments. This distribution makes it possible to create a balanced mix between residential and services, avoiding the formation of monofunctional quarters and ensuring a constant animation of the area, contributing to a more dynamic and attractive urban fabric.

An adequate road system has been planned to facilitate the connection with the surrounding urban context and support the new functional layout. Sub-area 2 is provided with a cycle track, given the presence of a pre-existing cycle network outside the area, which is thus implemented to improve the connection with the rest of the city and ensure greater continuity in the cycle routes. At the same time, larger and well-organised pedestrian spaces are created, making the area more accessible for pedestrians and increasing their safety and comfort.

3.2 Scenario 1

This scenario (see Fig. 3) represents an evolution of Scenario 0 in that urban devices are introduced that improve efficiency through the conversion of various impermeable, extensive and flat roofs into green roofs, and in photovoltaic roofs for public buildings.



(a)



(b)

Fig. 1. (a) Territorial framework. Identification of the location of the intervention area in the municipality of Nocera Inferiore (outline in white); (b) Intervention area: sub-area 1 (top – outline red) and sub-area 2 (bottom – outline red) (Color figure online).

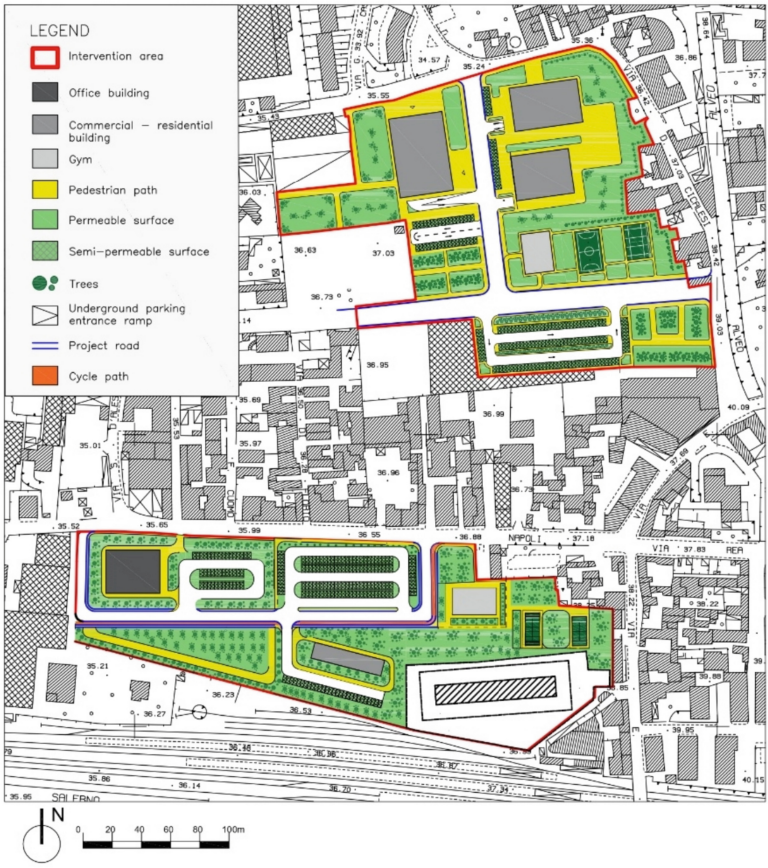

Fig. 2. Project plan of Scenario 0 (source: Author's elaboration)

Water mirrors and collection tanks have been provided. An urban garden is planned to promote inclusion and well-being, as well as to promote a short food chain and sustainable, ecological agriculture.

An intermodal node is also planned. These places ensure the integration of public and private transport by overcoming the purely transport-related aspect of interchanges, which are useful not only for the fluidification of travel and the improvement of the use of public transport, but also for the quality of life, health and safety of citizens.

The presence of an intermodal node shelter favors integrated mobility and implies the presence of an interconnection between at least two or more different services and transport systems, in this case between pedestrian mobility, mobility using public transport and cycle mobility. The shelter is designed in such a way as to have the following requirements: stopping bay; pavement; connection with cycle path; waiting area protected by shelter, with photovoltaic covering, partially closed to protect against wind and rain, equipped with seating and illuminated; presence of bicycle racks and parking

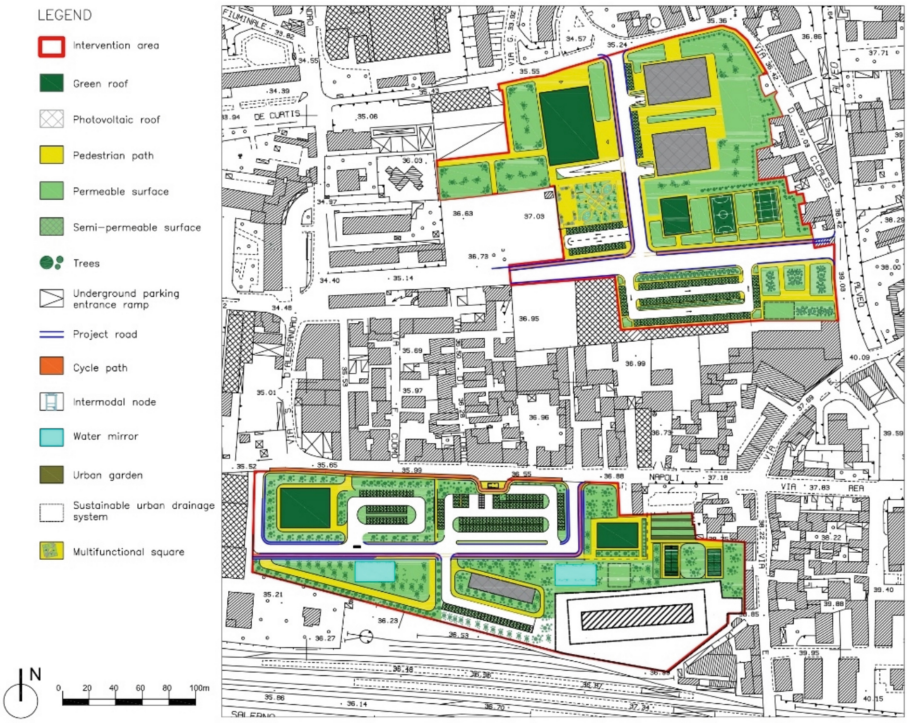

Fig. 3. Project plan of Scenario 1 (source: Author's elaboration)

spaces, also connected to a possible bike sharing service; or electric vehicle charging station.

3.3 Scenario 2

Finally, the third scenario (see Fig. 4) represents the culmination of the design evolution, improving the connections between the different urban functions, enhancing the bicycle network with more efficient connections between the subdivisions, and introducing an Urban Center as a strategic point for governance and active participation of the municipality.

4 Results and Discussions

To exemplify the proposed procedure, different planning scenarios were formulated. The scenarios are differentiated by design choices involving surfaces, volumes, roofs and urban devices. For clarity, a summary table (Table 2) of the urban devices implemented in the three scenarios is given below.

It should be emphasised that the application of the methodology at the neighbourhood scale is a methodological choice closely linked to the operational and implementation

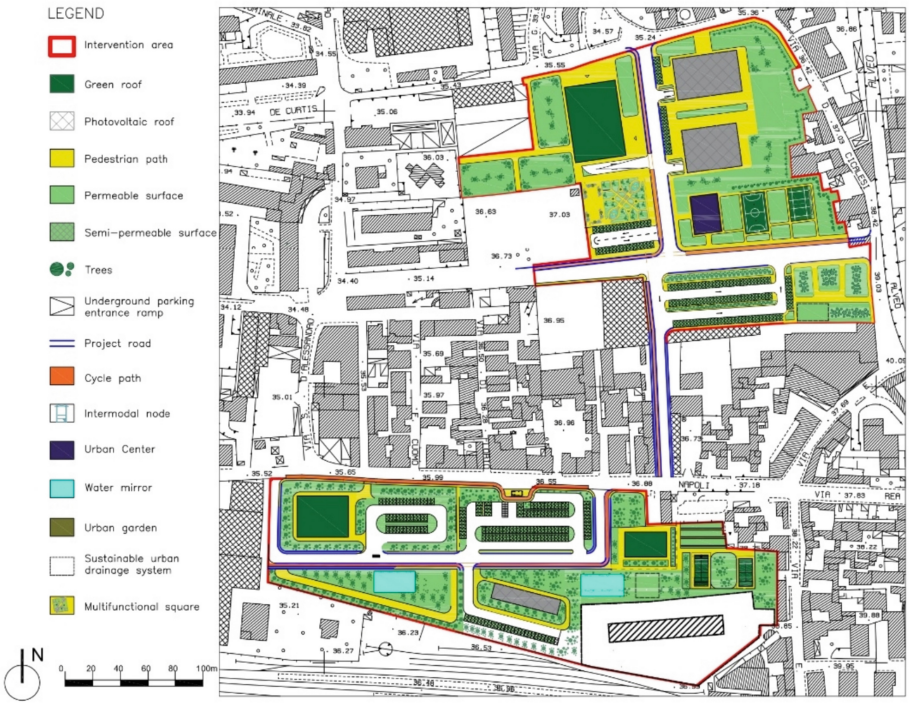

Fig. 4. Project plan of Scenario 2 (source: Author's elaboration)

nature of urban planning and to the need for direct controllability of the indicators used. The neighbourhood is the territorial context in which the implementation tools envisaged by urban planning are concretely applied, it is the scale at which it is possible to concretely intervene in order to modify urban structures, without losing the readability and governability of the context. It is only at the neighbourhood scale that the indicators used in the methodology can be measured and controlled through rules and regulations. On larger scales, these indicators would become too aggregated or inconsistent with direct urban planning action: for example, the percentage of permeable surface area of an entire municipality does not provide useful operational indications for intervening on a specific urban area. In this way, the object of study would change, no longer having the same level of detail nor the same capacity to affect punctual settlement patterns, and the methodology would have to be completely rethought to reflect the dynamics of the new scale.

The analysis of the three scenarios offered the opportunity to assess how efficient the different urban configurations are. Looking at the overall results, we can verify the increasing trend in the values of the normalised total efficiency index $EI_{t,n}$ (Table 3) (Fig. 5).

Scenario 0, derived from the simple application of the NTAs, presents a low level of efficiency, due to a lack of infrastructure, scarcity of public spaces and poor integration

Table 2. Urban devices implemented in different scenarios.

N.	URBAN DEVICE	SCENARIO 0	SCENARIO 1	SCENARIO 2
1	Cycle paths	X	X	X
2	Pedestrian spaces	X	X	X
3	Intermodal nodes	–	X	X
4	Recycling and composting infrastructure	–	–	–
5	Building geometry	X	X	X
6	Urban compactness	X	X	X
7	Photovoltaic roof	–	X	X
8	District heating	–	–	–
9	Water mirrors	–	X	X
10	Green roof	–	X	X
11	Sustainable urban drainage system	–	X	X
12	Water collection and reuse system	–	–	–
13	Permeable surfaces	X	X	X
14	Ecological habitat	–	–	–
15	Urban gardens	–	X	X
16	Ecological micro-corridors	–	–	–
17	Tree density	X	X	X
18	Multifunctional square	–	X	X
19	Urban center	–	–	X
20	Functional mixité	X	X	X
21	Social mixité	X	X	X
22	Water square	–	–	–

Table 3. Comparison of results between the three scenarios analysed.

	Scenario 0	Scenario 1	Scenario 2
	EI_k	EI_k	EI_k
Artificial Capital	0,18	0,36	0,39
Natural Capital	0,17	0,50	0,50
Social Capital	0,13	0,27	0,47
$EI_{t,n}$	**0,48**	**1,13**	**1,36**

of natural elements into the urban environment to highlight the fact that considerations of settlement efficiency are neglected within the regulation.

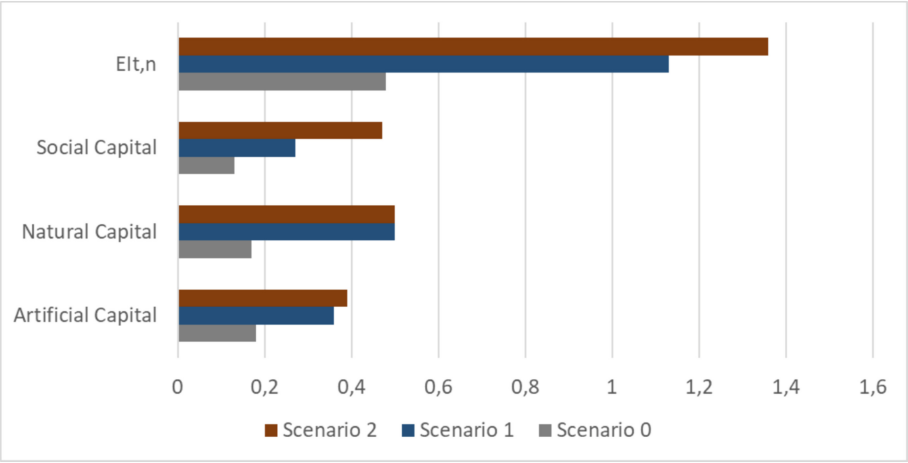

Fig. 5. Comparison of the 3 scenarios (source: Author's elaboration)

As far as Scenario 1 and Scenario 2 are concerned, it can be seen, by reading the values obtained, that certain choices can guarantee a certain degree of success in terms of improving energy and environmental efficiency performance, towards a path ever closer to sustainability.

The introduction of new urban devices, infrastructures and services (bicycle lanes, water squares, green roofs, efficient intermodal nodes, urban centres, etc.) and the correct management and possible implementation of existing devices lead to a systematic improvement of settlement efficiency.

This result demonstrates how a strategic and integrated approach can truly maximise urban performance, ensuring a more sustainable, accessible and resilient environment.

5 Final Remarks

In this contribution, a methodology has been proposed that allows for quantifying the added value resulting from the gradual introduction of urban devices, providing a clear view of the efficiency of the strategies adopted and creating a basis for future planning and design decisions. The integration of mixed-use developments, green infrastructure, and sustainable mobility solutions plays a fundamental role in shaping urban areas that are more liveable, accessible, and environmentally friendly.

In particular, the article concerned the application of the model to a case of urban regeneration. Urban transformation resulting from the reutilization of urban areas, formerly occupied by industrial complexes, represents a great opportunity for regeneration and urban renewal, to balance the physical and functional structure of the existing city. Mostly these areas are real voids to be returned to the city, assigning new functions, catalysts of different activities and generators of a substantial housing income, and defining new spaces, both for public and private use, aimed at combining social and collective urban interaction.

The model development perspectives are embedded in the potential of the methodology and in the way it is structured. Hence, the proposed model is configured as a controlling tool, in quantitative terms, of the effects induced by town planning choices on the degree of settlement efficiency. In this way, it is possible to make the necessary changes to increase the quality of the solutions identified in the municipal urban plan. In this sense, it is emphasised that this model is designed to be applied exclusively on an implementation level for two reasons. Firstly, the difficulty of managing this approach to the whole city, as its application to a neighbourhood or settlement implies fewer variables to be controlled.

Secondly, from the perspective of "think globally, act locally", it is considered necessary, in order to increase the resilience of the city as a whole, to act first of all on individual neighbourhoods and settlements.

On the basis of the model, the domain of intervention is defined by the possibility of affecting the physical and functional organisation of the settlement. The contents, that is, are all those that can credibly be found in the technical rules of a plan and, consequently, define the settlement in all its parts in an urban planning controllable way.

The full implementation within a settlement of the urban devices imagined in the model presupposes upstream conditions that consist of far-sighted policies and regulations that substantiate them. It also presupposes that interventions are allowed or foreseen in the superordinate planning tools so that they can be effectively implemented through urban implementation plans or urban projects.

Through a comparative analysis of the elaborated scenarios, it was possible to observe how different design choices influence the ability of the intervention to meet the needs of liveability, environmental resilience and social inclusion.

While the results obtained are not intended to represent absolute values, the proposed model serves as a valuable tool to systematically monitor all design aspects contributing to the efficiency of an urban settlement. The practical application of this model provides decision-makers with a more precise understanding of the effects of urban transformations.

This study, in fact, is limited to checking the contents of the urban plan, putting forward proposals in support of the project, with respect to the three themes considered relevant. Specifically, the usefulness of the presented model will lie in the possibility of its use both for evaluations and to support decision-making. In the first case, it can provide a tool to integrate strategic environmental assessment to the areas for which the municipal urban plan refers to detailed forecasts or make up for its absence on a municipal level by allowing for the evaluation of urban implementation plans. In the second case, it can provide quantitative information on the effects induced by the urban choices on the environment. These allow for the appropriate changes to be made in order to raise the quality level of the settlement. Therefore, in order to make these assessments comparable, it is necessary to base the construction of indicators on an ontology of urban structure. Finally, they can be used to stimulate participation as an indispensable element to support decision-making processes in the allocation of priorities and in the selection of possible alternatives.

Acknowledgments. Thanks to Carmela Giliberti for drawing up the calculations and design plans.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Oliverio, M., Conticelli, E.: Steering net zero land take urban growth. a decision support method applied to the city of Castelfranco Emilia, Italy. In: Marucci, A., Zullo, F., Fiorini, L., and Saganeiti, L. (eds.) Innovation in Urban and Regional Planning. pp. 171–182. Springer Nature Switzerland, Cham (2024). https://doi.org/10.1007/978-3-031-54096-7_16
2. Nuvolari-Duodo, I., et al.: Integrated climate change mitigation and public health protection strategies: the case of the City of Bologna, Italy. IJERPH **21**, 1457 (2024). https://doi.org/10.3390/ijerph21111457
3. Carter, J.G., Cavan, G., Connelly, A., Guy, S., Handley, J., Kazmierczak, A.: Climate change and the city: building capacity for urban adaptation. Prog. Plan. **95**, 1–66 (2015). https://doi.org/10.1016/j.progress.2013.08.001
4. UN-Habitat: Urban regeneration as a tool for inclusive and sustainable recovery. https://unhabitat.org/urban-regeneration-as-a-tool-for-inclusive-and-sustainable-recovery, (2021)
5. Roberts, P., Sykes, H.: Urban Regeneration: A Handbook. SAGE Publications Ltd, 1 Oliver's Yard, 55 City Road, London EC1Y 1SP United Kingdom (2008). https://doi.org/10.4135/9781446219980
6. UN-Habitat: Urban Regeneration for Localizing the Sustainable Development Goals (2024)
7. Fasolino, I., Grimaldi, M.: The urban planning efficiency of settlements. Techniques and actions. ARCHIVIO DI STUDI URBANI E REGIONALI, 5–10 (2020). https://doi.org/10.3280/ASUR2020-127-S1001
8. Fasolino, I., Coppola, F., Grimaldi, M.: A model for urban planning control of the settlement efficiency. A case study. In: Archivio di studi urbani e regionali, pp. 181–210. FrancoAngeli, Milano, Italy (2020)
9. Schetke, S., Haase, D., Kötter, T.: Towards sustainable settlement growth: a new multi-criteria assessment for implementing environmental targets into strategic urban planning. Environ. Impact Assess. Rev. **32**, 195–210 (2012). https://doi.org/10.1016/j.eiar.2011.08.008
10. Singh, R.K., Murty, H.R., Gupta, S.K., Dikshit, A.K.: An overview of sustainability assessment methodologies. Ecol. Ind. **15**, 281–299 (2012). https://doi.org/10.1016/j.ecolind.2011.01.007
11. Cicalese, F., Fasolino, I.: A multidimensional assessment model of settlement efficiency at the urban scale. In: Marucci, A., Zullo, F., Fiorini, L., and Saganeiti, L. (eds.) Innovation in Urban and Regional Planning, pp. 251–262. Springer Nature Switzerland, Cham (2024). https://doi.org/10.1007/978-3-031-54118-6_24
12. El-Haggar, S., Samaha, A.: sustainable urban community development guidelines. In: Roadmap for Global Sustainability — Rise of the Green Communities. pp. 75–102. Springer International Publishing, Cham (2019). https://doi.org/10.1007/978-3-030-14584-2_6
13. Seto, K.C., Güneralp, B., Hutyra, L.R.: Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. Proc. Natl. Acad. Sci. U.S.A. **109**, 16083–16088 (2012). https://doi.org/10.1073/pnas.1211658109
14. Fang, K., Zhang, Q., Yu, H., Wang, Y., Dong, L., Shi, L.: Sustainability of the use of natural capital in a city: Measuring the size and depth of urban ecological and water footprints. Sci. Total. Environ. **631–632**, 476–484 (2018). https://doi.org/10.1016/j.scitotenv.2018.02.299
15. Olewiler, N.: Environmental sustainability for urban areas: the role of natural capital indicators. Cities **23**, 184–195 (2006). https://doi.org/10.1016/j.cities.2006.03.006

16. Bott, L.-M., Ankel, L., Braun, B.: Adaptive neighborhoods: the interrelation of urban form, social capital, and responses to coastal hazards in Jakarta. Geoforum **106**, 202–213 (2019). https://doi.org/10.1016/j.geoforum.2019.08.016
17. Wentink, C., Vaandrager, L., Van Dam, R., Hassink, J., Salverda, I.: Exploring the role of social capital in urban citizens' initiatives in the Netherlands. Gac. Sanit. **32**, 539–546 (2018). https://doi.org/10.1016/j.gaceta.2017.05.011
18. Stewart, T.J., French, S., Rios, J.: Integrating multicriteria decision analysis and scenario planning—Review and extension. Omega **41**, 679–688 (2013). https://doi.org/10.1016/j.omega.2012.09.003
19. Ram, C., Montibeller, G., Morton, A.: Extending the use of scenario planning and MCDA for the evaluation of strategic options. J. Oper. Res. Soc. **62**, 817–829 (2011). https://doi.org/10.1057/jors.2010.90
20. Hämäläinen, R.P., Lahtinen, T.J., Virtanen, K.: Generating policy alternatives for decision making: a process model, behavioural issues, and an experiment. EURO J. Deci. Processes. **12**, 100050 (2024). https://doi.org/10.1016/j.ejdp.2024.100050